COMPUTER-SUPPORTED LABORATORY FOR PRODUCTION-ORIENTED ELECTROTECHNICAL SYSTEMS.

DANNY SNYDERS
INGE MERTENS
RONNIE BELMANS

Katholieke Universiteit Leuven

Electrical Engineering Department (ESAT), Division ELEN
Kardinaal Mercierlaan 94, B3000 Leuven, Belgium

Abstract: **At the electrical engineering department of the K.U.Leuven an education research project was started in October 1997. The target is to develop a powerful environment to teach students to solve practice-oriented problems as they will encounter them in industry furtheron in their career. In order to give a wide use to the developed environment, a close collaboration has been established with three poly-technical engineering institutes.**

Self-dependence has to be stimulated by creating possibilities for real "hands-on experience". Such an educational environment implicates time-problems, high investment costs and last but not least safety restrictions. The project contributes to the solution of these problems by using simulation- and software-environments, without loosing the real hands-on feeling.

Keywords: engineering education, software environment, simulation, electrical laboratory

Symposium: F

I. INTRODUCTION

The nature of the problem is diverse. When a group of students have to perform some laboratory sessions there are some problems that come up. First of all the teaching assistant has to prepare the laboratory session. In these laboratories sometimes use is made of very expensive equipment that is not intrinsically safe because students can make damaging mistakes.

There are also some practical problems involved. The students have to be split into smaller groups, so a lot of laboratory sessions have to be scheduled. Also the crowded laboratories in spite of this splitting causes a problem.

Another drawback is the problem of missed sessions. When a student does not attend a laboratory session there is little chance he can attend at a later time.

Also the time elapsed between the laboratory experiments and the examination plays a role in the efficiency of the laboratory session.

A solution to this problems was to make a program simulating the laboratory. A first multimedia program was made in IconAuthor by some students. There were problems with this multimedia package. One of the problems was that the installation was rather difficult and far from straightforward. This is now solved.

For the virtual lab Authorware 5 was choosen. The possibilities were larger than these of IconAuthor. However, in practice some of the features of IconAuthor are not available.

The purpose of the virtual lab is to help the students to understand better the theory, as presented in the lectures, with the help of animations, to provide a short overview of all the equations, to present an overview of the systems used in industry and to help the students prepare, execute and repeat the laboratory sessions. With this multimedia program the reality should be simulated as much as possible.

The contribution of this paper is to show the work that has been done and the possibilities of the multimedia program.

II. THREE STAGE APPROACH

In the first stage the students perform the experiments using the multimedia program. This greatly enhances the level of knowledge when starting the tests, leading to a better understanding, faster execution and safer operation.

The second stage is the laboratory itself. The students see the similarities and the differences between the actual laboratory and the one simulated by the multimedia program. This improves their insight. The students already know a great deal about the purpose of the laboratory. Conclusions can be made faster in the actual laboratory as the students already have seen the graphs in the multimedia program.

In the third stage the students can repeat the laboratory at home. When, for example, a student has measured the equivalent circuit of a transformer, he can use this circuit to redo the laboratory in the virtual environment. The simulation is never the same as reality, but it is sufficiently close to draw some conclusions.

To give an impression of the Virtual Lab some examples of animations and simulations are given.

III. EXAMPLE 1: ANIMATIONS

The most difficult to explain to the students is the rotating field of an induction machine. For this purpose some animations are made to help understand this effect.

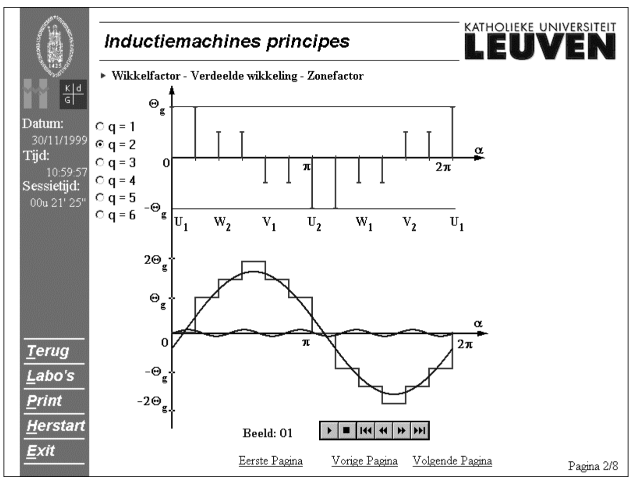

Fig. 1: Example of an animation to explain the rotating field of an induction machine.

A first animation is shown in Fig. 1. On the top curve the current distribution along the circumference of the induction motor stator is shown. At the bottom the flux density is given. Here the first and fifth harmonic component are shown. When the play-button is pressed, one sees that the first and third harmonic move in opposite directions. On this page, one can also see the influence of the use of more than one slot per voltage. On Fig. 1 the number of slots per pole and per phase is 2.

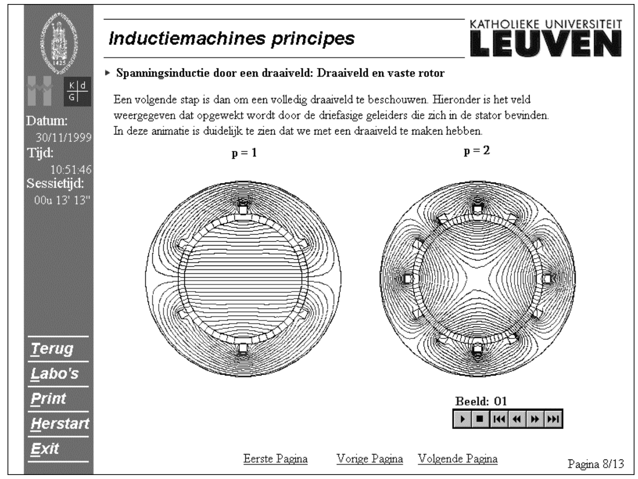

Fig. 2: Second example of an animation to explain the rotating field of an induction machine.

Another animation to explain the same phenomena is shown in figure 2. Here use is made of finite element software as used in our department to simulate the complex behavior of all kinds of machines, is the basis of the analysis. The results of the finite element solution are animated in the Virtual Lab. The left is an induction machine with one pole-pair and the right with two pole-pairs.

IV. EXAMPLE 2: TRANSFORMER

An example of a simulation is given on the figure 3.

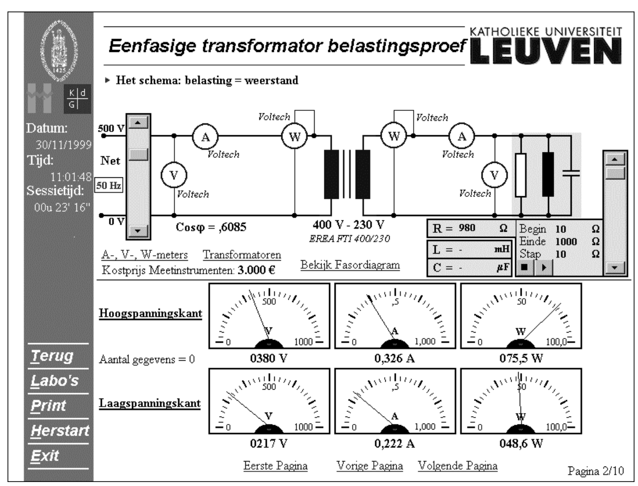

Fig. 3: Example of the simulation of a loaded Single phase transformer

On this picture one recognizes the transformer in the middle, the voltage controller on the left, the load controller on the right, the voltage, current and power meters and the output of these measurement devices. One can vary the load in steps between a maximum and minimum value and then look at the results in a table and a graph. To perform the load test in real life, requires some experience and time. In the Virtual Lab it takes five minutes to simulate and draw the graphs. Then the most important element of the laboratory session is attacked, being the conclusions as this is the final purpose of the laboratory session. To see what can be concluded based on these experiments. Without the program the students spend all their time measuring.

V. EXAMPLE 3: DIRECT CURRENT MACHINES

With direct current machines there are different connection systems possible. They effect the torque-speed characteristic. On figure 4 an example is given of the interactivity of the program. The students can change the voltage and immediately see how this effects the characteristic.

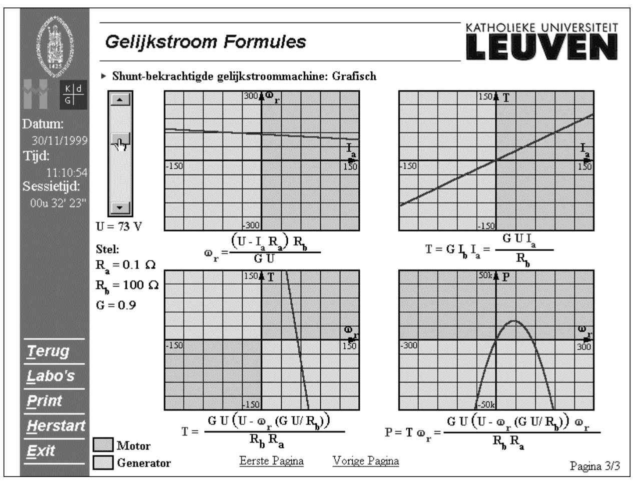

Fig. 4: Example of the graphs of a direct current machine.

On the upper left side of figure 4 is a slider to change the voltage of the direct current machine connected as a shunt. In the upper left is the speed-current graph, in the upper right the torque-current graph, in the lower left the torque-speed graph and the lower right the power-speed graph. Also the equations and the zones where the direct current machine operates as a generator or motor, are given.

VI. EXAMPLE 4: MICROCONTROLLERS

A further example of the interactivity of the Virtual Lab is shown on figure 5. On this picture a NOR-gate is shown. When one clicks on the universal symbol of a NOR-gate, it is shown which transistor becomes active.

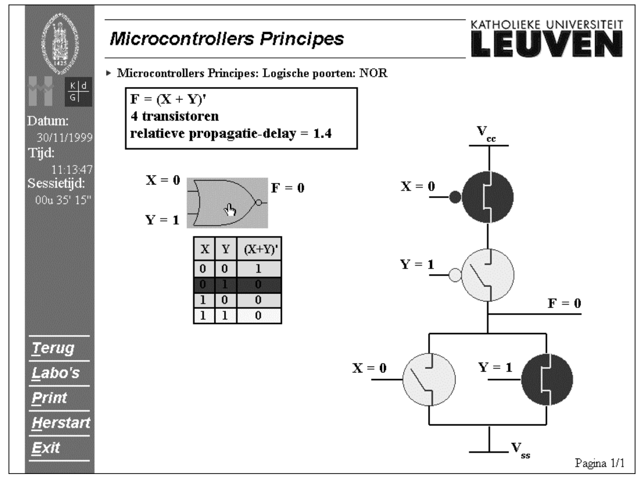

Fig. 5: Example of a NOR-gate

VII. CONCUSIONS

The conclusions are that this program is effective: the reaction of the students is very positive and it is concluded that students find this a useful tool to enhance their knowledge about sometimes complex matter.

In future more effort will be spend on further laboratory sessions. To improve the Virtual Lab 3D-animations and speech will be used. Translation of the different laboratories in English is also possible. The first laboratory about electrical transformers is already translated in English.

Because the Virtual Lab is a cooperation of the Katholieke Universiteit Leuven and three polytechnical institutes, the universality of the laboratories must be guaranteed. A lot of effort is put in making the laboratories universal.